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Final Technical Report for NASA Grant NAG5-1899
Variability in the Multi-Component X-ray Spectra of AGN

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Covering Period March 1, 1993 to February 28, 1994

(NASA-CR-197313) VARIABILITY IN
THE MULTI-COMPONENT X-RAY SPECTRA
OF AGN Final Technical Report, 1
Mar. 1993 - 28 Feb. 1994
(Pennsylvania State Univ.) 3 p

N95-70723

Unclass

29/89 0039814

The main objectives of this grant were:

1. To study the soft X-ray spectra of Active Galactic Nuclei (AGN) discovered as part of the Ultrasoft Survey of the Einstein IPC database.
2. To look for evidence of variability in the soft X-ray region both on the timescales of the ROSAT observations (timescales < a day or so), and between the Einstein and ROSAT observations (a timescale of ~12-13 years).
3. To use the X-ray continuum measurements of these AGN in combination with other multiwavelength continuum data to model the physical mechanism(s) responsible for ultrasoft X-ray emission.

The main results were:

1. The soft X-ray spectra of the AGN observed by us with ROSAT were well modeled with power-law spectra. However, the spectral indices of these fits were (in most cases) much steeper than those required to fit AGN spectra at energies above ~2 keV. e.g. the spectral photon index for the fit to E0132.8-4111 is 3.9 (Thompson et al. 1994) while the "canonical" high energy photon index for AGN is 1.7
2. It was found that the ROSAT-observed AGN in our sample had non-variable X-ray count rates over the course of their ROSAT observations. However, some did show significant variability when compared to their Einstein IPC count rates of ~12-13 years previous (Note: care was taken to properly compare the Einstein and ROSAT count rates; Thompson et al. 1994).
3. The ROSAT data of the AGN in our sample (and ROSAT data on other sources taken from the ROSAT public archive) were combined with data in the infrared, optical, and ultraviolet regions in order to carry out multiwavelength continuum modeling. The purpose of this modeling was to see whether the ultrasoft X-ray emission ($E < 0.5$ keV) of AGN could be accounted for in the context of the black hole plus accretion disk paradigm. It was found that simple, "bare" accretion disks could not account for this emission (Note: this had been reported in the literature previously by several groups). It was found, however, that the addition of a thin, hot ($kT \sim 120$ keV) corona to the accretion disk model has the effect of comptonizing (i.e. upscattering) the photons emitted from the disk and can produce enough soft X-ray photons to account for both the flux levels and spectral slopes observed in these objects (Thompson 1994). This result represents the first such attempt at detailed multiwavelength accretion disk modeling to incorporate a comptonizing corona (Note: other groups have discussed such models in the literature, but have only made estimates of their effects without carrying out detailed models).

The work carried out under this grant, in combination with our work on the Einstein observations of AGN, has increased our knowledge of the spectral characteristics of X-ray-selected AGN in general and of the emission properties and possible emission mechanisms of ultrasoft AGN in particular.

List of publications resulting from or directly related to the research funded by the NASA AGN grant:

Córdova, F. A., Kartje, J. F., Thompson, R. J., Mason, K. O., Puchnarewicz, E. M., and Harnden, F. R. 1992, "Active Galactic Nuclei with Ultrasoft X-ray Emission", *ApJ Supp.*, 81 661

Thompson, R. J. 1993, "CO Observations of Ultrasoft AGN", *MNRAS*, 264, 999

Thompson, R. J., Puchnarewicz, E. M., Córdova, F. A., and Mason, K. O. 1994, "ROSAT Observations of X-ray Selected Active Galactic Nuclei", *ApJ*, 420, 136

Thompson, R. J. and Córdova, F. A. 1994, "A Statistical Analysis of the Broadband 0.1 to 3.5 keV Spectral Properties of X-Ray-Selected Active Galactic Nuclei", *ApJ*, in press

Thompson, R. J. 1994, "Soft X-ray Analysis and Multiwavelength Modeling of Soft X-ray Selected Active Galactic Nuclei", Ph.D. Thesis, The Pennsylvania State University

Córdova, F. A. and Thompson, R. J. 1992, "Towards a Complete Sample of Ultrasoft X-ray-Emitting AGN" in *Proceedings of the 2nd Annual Astrophysics Conference in Maryland, Testing the AGN Paradigm*, ed. S. Holt, (New York: American Institute of Physics), p. 200

Thompson, R. J., Córdova, F. A., Puchnarewicz, E. M., and Mason, K. O. 1992, "Multiwavelength Observations of Ultrasoft X-ray Emitting Active Galactic Nuclei", *BAAS*, 24, 729

Thompson, R. J. 1994, "A Survey of the Broadband 0.1 to 3.5 keV Spectra of X-ray-Selected AGN", *BAAS*, 25, 1390